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Japanese sleep disturbance and fatigue disability weights in evaluating the effects of increasing temperatures on health by a life cycle approach

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Abstract
Purpose This study aimed to establish a set of disability weights (DWs) for sleep problems and fatigue which could be applied in composite health outcome measures in order to quantify the burden of symptoms and economically evaluate the effects of increasing temperatures on a life cycle approach.
Methods The conditions were evaluated by a two-step questionnaire study. In the first step, specialists determined the DW for each condition. The second step was identical to the first, except that the determinations were made by primary care physicians. Both groups of medical practitioners used an interpolation method consisting of a comprehensive set of 31 disease-specific DWs.
Results and discussion Mean DWs for sleep disturbance were 0.101 for environmental sleep disturbance, 0.069 for mild sleep disturbance, and 0.086 for moderate sleep disturbance. Mean DWs for chronic fatigue syndrome (CFS) were 0.099 for a diagnosis of CFS, 0.164 for mild handicap, 0.281 for moderate handicap, and 0.459 for severe handicap. Mean DWs assigned by primary care physicians for sleep disturbance were 0.114 for environmental sleep disturbance, 0.140 for mild sleep disturbance, and 0.126 for severe sleep disturbance. Those for CFS were 0.154 for a diagnosis, 0.099 for mild handicap, 0.147 for moderate handicap, and 0.226 for severe handicap.
Conclusions Using the present valuation protocol, it appeared feasible to establish the burden of symptoms as attributable to increasing temperatures. The results can be applied in composite health outcome measures for public health research, environmental research, and economic evaluations.

Keywords Burden of symptoms · Increasing temperatures · Life cycle approach · Public health

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1 Introduction

Health impacts related to climate change have been given increasing attention during recent years (Hajat et al. 2010; Kim et al. 2011). Such impacts have been widely known in life cycle impact assessment (LCIA) field which dealt with the assessment of human health impact by climate change in most of the current endpoint-type LCIA tools (Goedkoop and Speiensma 1999; Steen 1999; Itsubo and Inaba 2010).

Fatigue and sleep disturbance are major complaints in hot weather (Dapi et al. 2010) and our data revealed that 30 % of in Japanese adults surveyed experienced fatigue and 60 % slept poorly in summer (data not shown). The health impact of fatigue and sleep disturbance due to hot weather or climate change is little considered as compared with

infectious diseases, such as malaria (Stresman 2010; Kim et al. 2011; Xu et al. 2012) and heat stress. Because the former conditions are rarely fatal and fatigue and sleep problems have not been recognized as the disorders or diseases. DWs have been mainly determined in various medical conditions. The other reason is that the definition of fatigue and sleep problems might be large in scope and be difficult to determine. There have been no LCIA tools which deal with these mild health impacts caused by climate change to our knowledge. Nonetheless, because fatigue and sleep disturbance can continue indefinitely and the prevalence in general population might be high, we cannot disregard the impact of these conditions on daily life related to climate change or increasing temperatures.

Human health impacts have been assessed with disability-adjusted life year (DALY) in most of endpoint-type LCIA tools above described. The DALY combines the (estimated) number of years of life lost (YLL) lost due to premature death and the number of the years lost due to disability (YLD; Murray 1996). YLL is the product of the number of deaths and their standard life expectancies at age of death in years, while YLD is the product of the number of incident cases, their disability weights (DWs), and their average duration of the case until remission or death (years). DWs represent the consequences of the relative severity of each disease (Stouthard 2000). Most of LCIA tools dealt with only death caused by climate change and assess its impacts with YLL in practice (Fig. 1a). Because fatigue and sleep disturbance do not result in death immediately, these DALY should be calculated as YLD. Therefore, not only the prevalence of fatigue and sleep disorders due to hot weather, the determination of the weights of these disorders is necessary when assessing these impacts in endpoint-type methodology (see Fig. 1b).

Whether to quantify the burden of disease or to estimate the potential health benefits of investments in health care services, mortality-based measures of a population's health are no longer considered adequate (Stouthard 2000). Cost-effectiveness analyses have introduced the concept of quality-adjusted life years (QALYs) instead of the number of life years lost due to premature death (Stouthard 2000). The Global Burden of Disease (GBD; World Health Organization 2004) study has shown the potential value of this type of composite health outcome measure, particularly the DALY, in the area of public health research (Murray and Lopez 1997b). The GBD study provided quantitative, internally consistent estimates of the burden of disease, including nonfatal health outcomes, attributable to 107 causes per both sex for different age groups and world region in 1990. However, it did not determine the DWs for fatigue and sleep problems.

The objective of the present study was to establish a set of DWs for sleep disturbance and chronic fatigue syndrome (CFS) which could be applied in composite health outcome measures in order to quantify the burden of symptoms and eventually evaluate the effects of increasing temperatures or hot weather on health using a single economic index.

2 Methods

DWs have been reported for hundreds of medical conditions (Murray and Lopez 1997a; Stouthard 2000), ranging from minor impairments of health, such as gingivitis, to severe

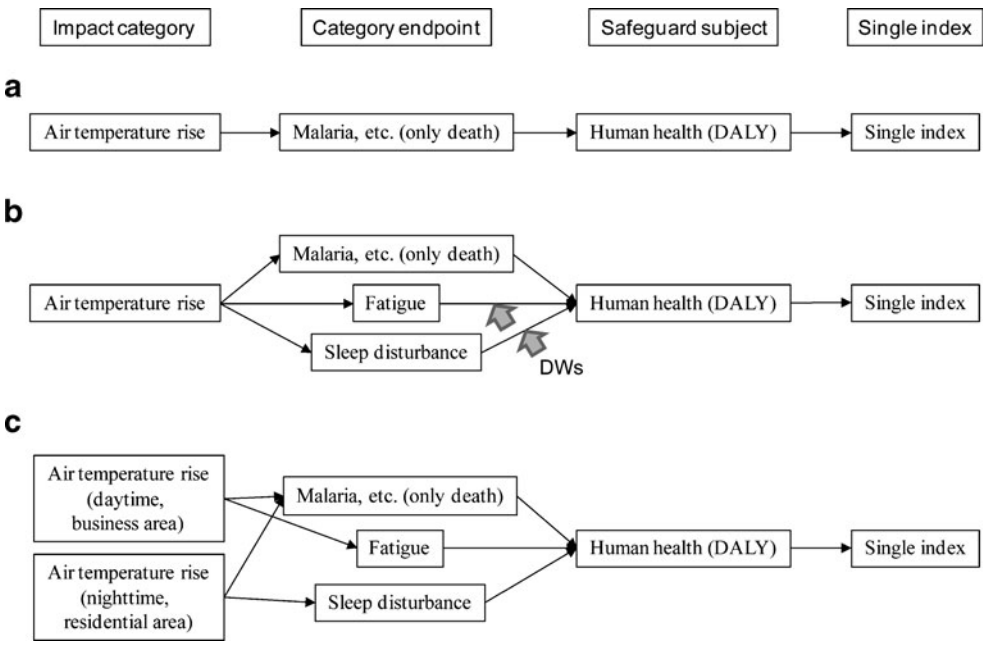

Fig. 1 Framework of LCIA of human health caused by climate change. **a** Conventional LCIA for climate change. **b** LCIA including fatigue and sleep disturbance. **c** LCIA for climate change depending on time and place

disabilities. Schizophrenia, depression, and primary insomnia were added to the list of $DWs_{Netherland}$ in a Dutch survey (Stouthard 2000), because these conditions are closely related to fatigue and sleep disturbance (Table 1). The procedure we adopted comprised the following steps previously reported by Mueller-Wenk (2002). The person-trade off method have been used for assessment of DWs in WHO (global burden of diseases 2004 update—disability weights for diseases and conditions 2004) or Netherlands (Stouthard 2000); however, the method needs many questions and it is not suitable for determining DWs by primary care physicians and specialists who were not concerned with the study.

Table 1 Disability weights for 31 disease stages (modified from Mueller-Wenk (2002))

Description of condition	Disability weight
Full health	0
Dental disease: periodontal disease (gingivitis)	0.00
Dental disease: periodontal disease (pockets, >6 mm deep)	0.01
Mild vision disorder (some difficulty reading small print, no difficulty recognizing faces at 4 m)	0.02
Adult-onset mild hearing loss (25–34 dB HL)	0.02
Mild to moderate asthma (symptom-free with or without maintenance therapy)	0.03
Adult-onset mild hearing loss (35–44 dB HL): (some difficulty understanding or actively participating in a conversation with one or more persons)	0.04
Benign prostatic hypertrophy (symptomatic)	0.04
Chronic hepatitis B infection without active viral replication	0.06
Uncomplicated diabetes mellitus	0.07
Mild stable angina pectoris (NYHA 1–2)	0.08
Mental retardation (IQ 70–84)	0.09
Primary insomnia	0.1
Problem drinking (physical, psychological, or social problems caused by excessive alcohol intake)	0.11
Mild to moderate congenital or early acquired hearing disorder	0.11
Moderate hearing disorder in the elderly (some difficulty understanding or participating in a conversation with one person but great difficulties with conversations with more than one person)	0.12
Unipolar depressive disorders: mild depressive episode	0.14
Unipolar depressive disorders: dysthymia	0.14
Osteoarthritis (grade 2) of hip or knee	0.14
Diabetes mellitus with neuropathy	0.19
Diabetes mellitus with nephropathy	0.29
Mild mental handicap (IQ 50–69)	0.29
Unipolar depressive disorders: moderate depressive episode	0.35
Severe asthma (not symptom-free despite maintenance medication)	0.36
Severe hearing disorder acquired as an adult (great difficulty understanding or participating in a conversation with one person)	0.37
Chronic hepatitis B with active viral replication	0.36
Severe vision disorder (unable to read small newspaper print, great difficulty recognizing faces at 4 m)	0.43
Moderate mental handicap (IQ 35–49)	0.43
Schizophrenia	0.528
Severe stable angina pectoris (NYHA 3)	0.57
Paraplegia, stable stage	0.57
Unipolar depressive disorders: severe depressive episode	0.76
Extreme mental handicap (IQ<20)	0.76
Tetraplegia, stable stage	0.84
Severe dementia (permanent supervision required)	0.95
Death	1

2.1 The procedure of determining DWs_{Japan}

Step 1 The conditions of sleep disturbance and fatigue were first described as precisely as possible to reduce the chance that they could be misinterpreted. We defined two types of sleep disturbance in this study: (1) "environmental sleep disorder" as categorized by the ICSD-2 (International Classification of Sleep Disorders; American Academy of Sleep Medicine 2001) and (2) status of sleep disturbance in accordance with the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J), which was further subdivided into mild sleep disturbance (PSQI-J score of 5.5–7.4) and moderate sleep disturbance (PSQI-J score of ≥7.5; Doi et al. 2000, 2001; Buysse et al. 1989). We used questions on three topics (number of hours slept, frequency of being unable to fall asleep within 30 min after going to bed, and sleep quality) to determine both mild (cut off, 5.5) and moderate sleep disturbance (cut off, 7.5). It was difficult to ask all questions including in PSQI-J for determining DWs; thereafter, we selected minimum suitable questions which have equal examining power to the total questions. We selected these three questions based on the previous study data in 2008 (Okano et al. 2008). One thousand healthy adult subjects completed PSQI-J through the survey company (Wish, Inc., Osaka, Japan). The cut off 5.5 is the international determined point (Buysse et al. 1989) and the cut off 7.5 was the average point in our 2008 study. By using the total score of the above questions, 91 % of subjects were divided as mild sleep disturbance (cut off, 6.5; sensitivity, 0.87; and specificity, 0.81) and 94 % of subjects were divided as moderate sleep disturbance (cut off, 7.5; sensitivity, 0.86; and specificity, 0.88; our unpublished data).

We defined fatigue based on either a diagnosis of CFS (Fukuda et al. 1994) and the DWs classification in Australian reports of CFS ($DWs_{Australia}$; Begg et al. 2007). The definition used by the Australian reports encompassed the following degrees of severity; "Having chronic fatigue and severe or profound handicap (requiring assistance for daily activities)", "Having chronic fatigue and moderate handicap (restricted in usual role activities)", and "Having fatigue and mild handicap or disabled without handicap (functional limitations)" (Begg et al. 2007).

Step 2 A common database was then created so that it would be possible to add the DWs for sleep disturbance and fatigue into the structure of the existing DWs. To this end, a range of well-known disability conditions was selected from the existing DW tables and sorted into ascending DW order. Care was taken to ensure that the entire range from DW0 to DW1 was covered, with particularly fine distinctions being made in relation to the subcategory of less severe disabilities, within which it was suspected that sleep disturbance and fatigue would fall. This sorted table of existing DWs is a suitable way of placing the hitherto unweighted conditions of sleep disturbance and fatigue in appropriate position within the ranking of heath conditions based on an assessment of their relative severity. Through the ranking process, lower and upper limits are obtained for the requisite DWs, and the desired value can then be established within this space by a process of rough interpolation.

The above process of ranking and interpolation was undertaken by medical practitioners (details are provided below) for two reasons. First, the groundwork had already been carried out by Murray (1996) using panels of physicians, thus using medical practitioners in the present study fulfilled a methodological prerequisite concerning the comparability of pre-existing DWs with those that were to be established. Second, those who have undergone medical training and are involved in the practice of medicine are best equipped to understand descriptions of different health conditions and undertake comparisons of their relative severity. Although individuals who personally experience health impairments may well be best positioned to judge how severely this condition affects them, they may find it particularly difficult to undertake an objective comparison between this and other conditions that they have not personally experienced.

The first study designed to establish the DWs of sleep problems and fatigue had been conducted with the following panels: (a) seven researchers, physicians, and psychiatrists specializing in fatigue (to evaluate fatigue or chronic fatigue), (b) six sleep researchers and psychiatrists specializing in sleep (to evaluate sleep problems), and (c) 73 primary care physicians (to evaluate both symptoms). The selection criteria for the primary care physicians were as follows: (1) currently residing in Tokyo, Osaka, or Nagoya metropolitan areas; (2) aged 25 years or older; (3) having three or more years of clinical experience after primary training; (4) specializing in internal medicine; and (5) having written a medical certificate for grade of disability for patients or insurance companies. These criteria were chosen for the following reasons: (1) these cities are the three biggest metropolitan areas in Japan; (2) this age requirement excluded subjects who were not medical doctors, because the minimum age of acquiring a medical license is 25 years of age in Japan; (3) we sought to recruit only experienced doctors; (4) the Mueller-Wenk (2002) study specified that doctors should be internal medicine specialists; and (5) the same study recruited doctors working at the Swiss Accident Insurance Institute in Japan (Mueller-Wenk 2002), hence those who had issued medical certificates of grade of disability were the closest match possible.

A questionnaire made available to the primary care physicians also included demographic and other variables

Table 2 Demographic variables of primary care physicians surveyed

Variables	Category	
Age (mean±SD)		49.8±9.86
Years of clinical experience (mean±SD)		22.0±10.0
Number of medical certificates issued for severity of disease (to patients)	0	n=1
	1–5	n=7
	6–10	n=7
	11–50	n=13
	More than 51	n=29
Number of medical certificates issued for severity of disease (to insurance companies)	0	4
	1–5	14
	6–10	6
	11–50	18
	More than 51	15

including age, place of residence, years of clinical experience, department, certification, number of times they had issued a medical certification for grade of disability, and personal experience of fatigue or sleep disturbance. The questionnaire was made available to 70 physicians via an internet site and recruitment was performed by an Internet survey company (M3, Inc., Tokyo, Japan).

A survey of specialists was conducted using an interview based on a questionnaire that drew on the studies of Mueller-Wenk (2002) for the evaluation of sleep disturbance and Begg et al. (2007) for evaluating fatigue. The questionnaire was given to specialists in fatigue and psychiatrists or physicians who diagnosed CFS or sleep disturbance. The details and the purpose of the present study as well as the meaning of DW were all fully explained.

3 Results and discussion

3.1 Small panel study

The coding assigned by panel participants for the DWs_{Japan} is presented in full in Table 2. The mean DWs_{Japan} were higher for environmental sleep disturbance than for mild sleep disturbance or moderate sleep disturbance, but not statistical significance (0.101 vs. 0.069 and 0.086, respectively). One psychiatrist responded that it was difficult to assign a DW to environmental sleep disturbance. This reflects the fact that while environmental sleep disturbance responds to changes in one's environment, these changes can be impossible to make. Hence, the DW of environmental sleep disturbance was higher than that of the other forms of sleep disturbance.

The mean DWs_{Japan} for fatigue was 0.099 for a diagnosis of CFS, 0.164 for mild handicap, 0.281 for moderate handicap, and 0.459 for severe handicap. We also asked specialists alone to assign a DW_{Japan} for acute fatigue as a reference score. The mean DW_{Japan} for this was 0.055.

3.2 Survey of primary care physicians

The questionnaires were made available to physicians who were registered with an internet research company (M3, Inc.

Table 3 Disability weights assigned by Japanese specialists (DWs_{Japan}) for various categories of sleep disturbance and fatigue

Specialist	Specialty	DW Sleep disturbance			DW Fatigue				
						Chronic fatigue syndrome			
		Environmental	Mild sleep disturbance (a)	Moderate sleep disturbance (b)	Acute	Diagnosis of chronic fatigue syndrome	Mild handicap	Moderate handicap	Severe handicap
A	Sleep	0.100	0.010	0.020	–	–	–	–	–
B	Sleep	0.150	0.030	0.050	–	–	–	–	–
C	Sleep	0.120	0.100	0.140					
D	Sleep	0.030	0.050	0.100					
E	Fatigue	–	–	–	0.015	0.050	0.055	0.060	0.080
F	Fatigue	–	–	–	0.010	0.070	0.115	0.380	0.560
G	Fatigue	–	–	–	0.090	0.120	0.140	0.170	0.350
H	Fatigue	–	–	–	0.040	0.140	0.350	0.500	0.750
I	Fatigue	–	–	–	0.030	0.070	0.130	0.360	0.600
J	Psychiatrist	0.100	0.150	0.150	0.100	0.150	0.200	0.300	0.500
K	Psychiatrist	0.105	0.075	0.055	0.065	0.095	0.160	0.200	0.370
Mean±SD		0.101±0.0004	0.069±0.053	0.086±0.067	0.050±0.036	0.099±0.038	0.164±0.093	0.281±0.148	0.459±0.216

Mild sleep disturbance was indicated by a score of 5.5–7.4 on the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) and moderate sleep disturbance was indicated by a score of >7.5

Tokyo, Japan). The internet research company was requested to collect samples up to 70; thereafter, the survey company sends the announcement about the study until they can collect 70 samples. For this goal, they sent 4,798 mails. Completed questionnaires were received from 73 physicians, and 57 were usable. The demographic variables of these physicians are shown in Table 3. The mean DWs_{Japan} assigned by these panel participants are presented in Table 4. Mean DWs_{Japan} in sleep disturbance were 0.114 for environmental sleep disturbance, 0.140 for mild sleep disturbance, and 0.126 for moderate sleep disturbance. We conducted a one-way analysis of variance (ANOVA) to examine the relationships between mean DW_{Japan} and number of medical certificates for severity of disease issued to patients, number of medical certificates for severity of disease issued to insurance companies, personal experience of sleep disturbance for external reasons, and personal experience of fatigue for external reasons for each disability category. Results showed no significant differences among DWs_{Japan} for all sleep categories except for number of certificates issued to patients. The highest DWs_{Japan} were assigned by physicians who had issued for severity of disease for patient at least 51 certificates.

Mean DWs_{Japan} assigned by primary care physicians specializing in fatigue were 0.154 for a diagnosis of CFS, 0.099 for mild handicap, 0.147 for moderate handicap, and

Table 4 Disability weights assigned by Japanese primary care physicians (DW_{Japan}) for various categories of sleep disturbance and fatigue

Variable	Category	No. of respondents	DW Sleep disturbance			DW Fatigue			
							Chronic Fatigue Syndrome		
			Environmental	Mild	Moderate	Diagnosis of Chronic Fatigue Syndrome	Mild handicap	Moderate handicap	Severe handicap
Total		57	0.114±0.095	0.140± 0.165	0.126± 0.132	0.154±0.141	0.099± 0.094	0.147± 0.126	0.226± 0.182
Number of medical certificates issued for severity of disease for patients	0	1	0.500	0.800	0.600	0.700	0.100	0.300	0.600
	1–5	7	0.097±0.067	0.090± 0.059	0.072± 0.065	0.123±0.050	0.074± 0.048	0.116± 0.113	0.251± 0.238
	6–10	7	0.041± 0.037	0.047± 0.050	0.045± 0.042	0.055± 0.044	0.048± 0.038	0.062± 0.041	0.081± 0.048
	11–50	13	0.099± 0.067	0.096± 0.054	0.107± 0.081	0.152± 0.128	0.109± 0.113	0.157± 0.139	0.242± 0.181
	51+	29	0.129± 0.089	0.172± 0.178	0.151± 0.140	0.168± 0.135	0.113± 0.101	0.165± 0.131	0.236± 0.171
			F=8.20,	F=7.71,	F=6.15,	F=6.72,	F=0.84,	F=1.47,	F=2.47,
			P<0.001	P<0.001	P<0.001	P<0.001	P=0.51	P=0.22	P=0.06
Number of medical certificates issued for severity of disease for insurance company	0	4	0.096±0.058	0.120± 0.054	0.100± 0.075	0.145±0.041	0.083± 0.051	0.142± 0.141	0.325± 0.307
	1–5	14	0.067±0.058	0.075± 0.100	0.075± 0.127	0.103±0.121	0.069± 0.077	0.098± 0.101	0.154± 0.143
	6–10	6	0.132±0.194	0.177± 0.308	0.144± 0.229	0.167±0.263	0.053± 0.045	0.138± 0.134	0.235± 0.254
	11–50	18	0.129±0.079	0.126± 0.079	0.116± 0.076	0.159±0.115	0.111± 0.092	0.164± 0.117	0.253± 0.162
	51+	15	0.138±0.087	0.208± 0.217	0.184± 0.146	0.195±0.141	0.134± 0.121	0.176± 0.152	0.233± 0.173
			F=1.30,	F=1.33,	F=1.37,	F=0.78,	F=1.41,	F=0.79,	F=0.94,
			P=0.28	*P*=0.27	*P*=0.26	*P*=0.54	*P*=0.24	*P*=0.54	*P*=0.45
Personal experience of sleep disturbance for external reasons	Yes	13	0.105±0.120	0.107± 0.127	0.086± 0.097	0.098±0.058	0.065± 0.052	0.092± 0.068	0.173± 0.136
	No	44	0.117±0.088	0.150± 0.175	0.138± 0.139	0.171±0.150	0.109± 0.101	0.163± 0.135	0.242± 0.193
			t=0.38	t=0.83	t=1.27	t=1.69	t=1.55	t=2.53	t=1.21
			P=0.71	*P*=0.41	*P*=0.21	*P*=0.10	*P*=0.13	*P*=0.02	*P*=0.23
Personal experience of fatigue for external reasons	Yes	23	0.120±0.094	0.124± 0.103	0.109± 0.081	0.134±0.108	0.087± 0.081	0.130± 0.111	0.209± 0.159
	No	34	0.110±0.098	0.151± 0.197	0.138± 0.157	0.169±0.159	0.107± 0.102	0.158± 0.136	0.238± 0.198
			t=−0.36	t=0.61	t=0.92	t=0.92	t=0.80	t=0.80	t=0.59
			P=0.72	*P*=0.55	*P*=0.36	*P*=0.36	*P*=0.43	*P*=0.43	*P*=0.56

Mild sleep disturbance was indicated by a score of 5.5–7.4 on the Japanese version of the PSQI-J and moderate sleep disturbance was indicated by a score of >7.5

0.226 for severe handicap. ANOVA showed no significant relationships between DW_{Japan} and neither number of medical certificates for severity of disease issued to patients or insurance companies nor personal experience of fatigue for external reasons. However, physicians with personal experience of sleep disturbance assigned lower DWs_{Japan} than those with only professional experience.

4 Discussion

We summarize the mean DWs_{Japan} assigned by specialists and primary care physicians in Fig. 2. The mean DWs_{Japan} assigned by specialists were 0.101 for environmental sleep disturbance, 0.069 for mild sleep disturbance, and 0.086 for moderate sleep disturbance (see Fig. 2). Those assigned by primary care physicians were 0.114 for environmental sleep disturbance, 0.14 for mild sleep disturbance, and 0.126 for moderate sleep disturbance (see Fig. 2). The DW set by the World Health Organization (DW_{WHO}) was 0.10 for primary insomnia and 0.055 for sleep disturbance by noise (Mueller-Wenk 2002; Murray 1996). Hence the present DWs for environmental sleep disturbance assigned by specialists and physicians are in accordance with both the DW_{WHO} for primary insomnia and the $DWs_{Netherland}$ (Mueller-Wenk 2002; Stouthard 2000). The DWs_{Japan} for sleep disturbance fell between the DWs_{WHO} for mild stable angina pectoris (New York Heart Association (NYHA) grades 1–2) and chronic hepatitis B infection without active viral replication. The present physicians did not assign significantly different DWs_{Japan} to mild and moderate sleep disturbance, which suggests that the DWs assigned might have been influenced by the experience of issuing medical certifications for severity of disease for patients. The limitation of this type of internet survey is that we could not confirm that all physicians understood the concept of DW and answered the questions by referring to the DW lists provided and the number of physicians who certificated the issued for severity of disease for patients less than 10 times (0, 1–5, and 6–10) were less than 10 person in each category; therefore, the reliability of statistical analysis have a limit to determine. The definition of environmental sleep disorder was not limit to cause by temperature increases; thereafter, the interpretation in DWs of sleep disturbance might be a little confused. We did not perform control interviews with the subjects from the primary care physician group to evaluate how these interpreted the questionnaire. These are limitations of the study. The mean DWs_{Japan} for CFS assigned by specialists were 0.099 for a diagnosis of CFS, 0.164 for mild handicap, 0.281 for moderate handicap, and 0.459 for severe handicap. Those assigned by primary physicians were 0.154 for a diagnosis of CFS, 0.099 for mild handicap, 0.147 for moderate handicap, and 0.226 for severe handicap. The mean $DWs_{Australia}$ for CFS were 0.360, 0.137, 0.449, and 0.76, respectively (Begg et al. 2007). Hence, the DW_{Japan} assigned by both specialists and physicians differed considerably from the $DW_{Australia}$ (Begg et al. 2007). The DW_{Japan} of CFS assigned by both specialists and primary physicians rose in conjunction with increasing severity of the condition, yet DW_{Japan} values assigned by primary physicians were

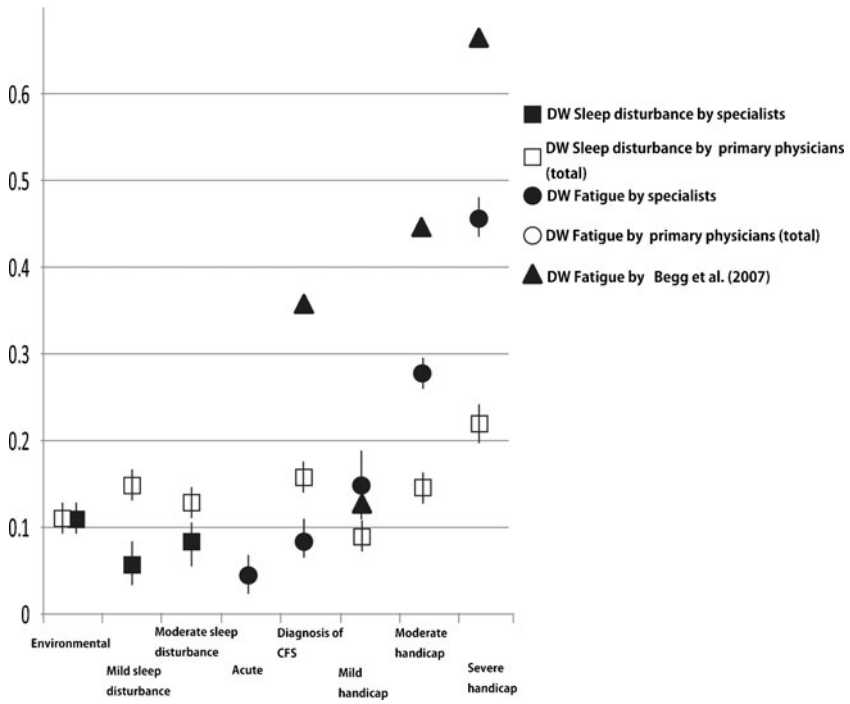

Fig. 2 The summary of DWs which were assigned by specialists and primary care physicians. *Black circle and square* the average DWs of fatigue and sleep disturbance which were assigned by specialists (*error bars* standard deviation). *White circle and square* the average DWs of fatigue and sleep disturbance which were assigned by primary care physicians (*error bars* standard deviation). *Black triangle* the DWs of fatigue which were assigned in Australia DWs of fatigue: diagnosis of CFS, CFS with mild handicap, CFS with moderate handicap, and CFS with severe handicap DWs of sleep disturbance: environmental sleep disturbance, mild sleep disturbance, and moderate sleep disturbance

approximately half those awarded by specialists. This might in part be explained by the infrequency with which a primary care physician would be expected to diagnose CFS, due to its low prevalence (Minowa and Jiamo 1996), and hence the doctors might have less knowledge of the condition than the specialists. The DW_{Japan} for CFS with mild handicap fell between the DWs_{WHO} for a mild depressive episode of unipolar depressive disorder and diabetes mellitus with neuropathy, the DW_{Japan} for CFS with moderate handicap is in accordance with the DW_{WHO} for diabetes mellitus with nephropathy, and the DW_{Japan} for CFS with severe handicap fell between the DW_{WHO} for severe vision disorder (unable to read small print, great difficulty in recognizing faces at a distance of 4 m) and schizophrenia.

5 Conclusions

Determination of DW is subject to a large margin of error in relation to differences in the assessors' experience and the knowledge of the conditions assessed. Although further studies are needed to determine the correct values, the relative economic loss caused by increasing temperatures could be calculated using the present values and methods. Specifically, when combined with data about change in the prevalence associated with air temperature rise, the impacts of fatigue and sleep disturbance caused by climate change will be able to be assessed based on endpoint-type LCIA methodology in the same way as death which uses mortality data (see Fig. 1b). They will eventually be evaluated with a single economic index of the LCIA methodology.

Moreover, the impacts of fatigue and sleep disturbance caused by air temperature rise are considered to be particularly large in urban areas because they have large populations and high temperatures due to climate change and urban heat island phenomena. The magnitudes of human health impacts are influenced by time and place as well as effects of various countermeasures to hot weather or climate change including greening and cool paint. It is impossible to judge the countermeasures' effects with an amount of reduction in daily maximum air temperature at one meteorological observation point, thereafter it is necessary to evaluate a reduction effect of human health impacts by countermeasures based on endpoint-type LCIA methodology and DALY calculation (Ihara and Genchi 2008). These DWs enable to assess the total impacts of air temperature rise which depends on time and place (see Fig. 1c). They eventually contribute for judging reasonable installation of the countermeasures which reduce the environmental impacts totally.

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